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METHOD FOR DETERMINING A RECOMMENDED CEMENT CONTENT FOR PORTLAND CEMENT CONCRETE PAVEMENTS

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section I of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This test method describes the procedure for determining the cement needed in pavement concrete with a given source of aggregate to comply with the design criteria.

B. APPARATUS

1. A power driven concrete mixer capable of thoroughly mixing batches of the prescribed size.
2. Concrete beam molds with nominal dimensions of 150 by 150 by 510 mm.
3. Concrete cylinder molds with nominal dimensions of 150 mm diameter by 300 mm length.
4. A testing machine and fixture conforming to AASHTO Designation: T 97.
5. A test machine conforming to the requirements of ASTM Designation: C 39.
6. Tamping rods about 0.6 m long and 15 mm to 16 mm in diameter with hemispherical ends.
7. A hardwood strike-off tool with approximate dimensions of 20 by 40 by 300 mm.
8. Scoops, trowels and sponges.

C. SAMPLING

1. Before sampling aggregate materials for this test, perform all other routine aggregate tests to assure that the aggregate passes the applicable specifications. Aggregate sampled for testing should be of essentially the same character and quality as that proposed for the pavement.
2. Obtain a representative sample of the aggregate that will yield the following minimum quantities:

Size	Mass (in kg)
37.5 by 25.0 mm	250
25.0 by 19.0 mm	150
19.0 by 9.5 mm	170
9.5 by 4.75 mm	100
Passing 4.75 mm	400

NOTE: Obtaining a sample of coarse aggregate of representative gradation is not of prime importance since the material is separated into individual size fractions and recombined for the test concrete.

D. LABORATORY PREPARATION

1. Perform the following tests on representative portions of the coarse and fine aggregate:
   a. California Test 206 (Specific Gravity and Absorption of Coarse Aggregate)
   b. California Test 207 (Specific Gravity and Absorption of Fine Aggregate)
2. Air dry the remainder of the aggregate and then separate this material by sieving on the following individual
sieve sizes 37.5 mm, 25.0 mm, 19.0 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm.

The passing 4.75 mm portion need not be separated if the required grading can be achieved.

3. The cement used in the testing program shall conform to the Standard Specifications for Type II Modified, and shall be composed of a blend of equal parts produced by the following five mills:

   a. Kaiser Cement
   Permanent, California

   b. Calaveras Cement Redding, California

   c. Southdown Victorville Cement Plant
   Victorville, California

   d. Riverside Cement Co.
   Oro Grande, California

   e. California Portland Cement Co. Colton, California

E. MIX DESIGN

1. Design the test concretes at cement contents of 300, 325, and 350 kg/m^3 except when concrete is used in freeze-thaw areas, then design the test concrete at cement contents of 350 and 375 kg/m^3.

2. The concrete test slump shall be 60 ± 15 mm.

   NOTE: The 60 mm slump is considered to simulate specification concrete in the field at point of delivery.

3. Use a Vinsol resin type air-entraining admixture in all mixes to impart $3\frac{1}{2} \pm \frac{1}{2}$ % total air, except that the total air content must be $5\frac{1}{2} \pm \frac{1}{2}$ % for concrete used in freeze-thaw areas.

4. Use a combined grading for the test concrete within the following limits:

Sieve Size	% Passing
37.5 mm	100
25.0 mm	72-78
19.0 mm	59-65
9.5 mm	44-50
4.75 mm	35-41
2.36 mm	25-35
1.18 mm	18-28
600 µm	12-20
300 µm	5-9
50 µm	1-3
75 µm	0-2

F. TESTING PROGRAM

1. Prepare three batches of concrete for each mix design, each on a separate day. Make each batch large enough to produce two 150 by 150 by 510-mm beams, and two 150 by 300-mm cylinders, leaving an excess of about 10 % of the total size of the batch after molding the specimens. Make the 300 kg/m^3 batch (or the 350 kg/m^3 batch in freeze-thaw areas) large enough to produce one 100 by 125 by 450 mm shrinkage bar per batch in addition to the above beams and cylinders.

2. Mix the concrete in accordance with AASHTO Designation: T 126.

3. Measure the slump per ASTM Designation: C 143 to the nearest 5 mm. Determine the density per California Test 518. Measure the air content per ASTM Designations: C 231 or C 173.

   NOTE: If air content is measured by C 173, the batch size must be increased by the volume used in the test.

4. Fabricate test specimens in accordance with AASHTO Designation: T 126.

5. Protect the specimens from loss of moisture by the use of wet blankets for beams and shrinkage bars, and by the use of lids on cylinder cans, for a period of 24 ± 4 h. At that time, remove the specimens from the molds and place them in a moist curing room.

6. Remove the beams and cylinders from the curing room at an age of 14 days and perform the appropriate tests. Test the flexural beams for modulus of rupture in accordance with AASHTO Designation: T 97.

7. Cure the shrinkage bars in the moist room for 7 days and then place them in a drying room (50 ± 4 % RH, 23 ± 1.7°C) for 28 days. Make length and mass measurements at ages of 1, 7, 14, 21, and 35 days.

8. Record complete test results, including averages of all test information, on a laboratory work card.

G. CRITERIA FOR RECOMMENDING CEMENT CONTENT

1. Assuming a coefficient of variation, V, of 15 %, and a willingness to accept a probability that four out of five, or 80 % of the test results will be 3.8 MPa or greater, the average 28-day modulus of rupture would have to be 4.3 MPa using third-point loading. Since it is desirable and practical to reduce the time required for the laboratory test as much as possible, a 14-day strength will be used. Again, assuming a 15 % increase in concrete strength in the period from 14 to 28 days, the average 14-day strength, as determined in the laboratory, should be 3.8 MPa. Therefore, the recommended cement content is that cement content (25 kg/m^3 increments) which will produce an average 14-day laboratory modulus of rupture of at least 3.8 MPa.

2. The recommended cement content shall be such that the water-cement ratio will not exceed 0.55 kg/kg, except in freeze-thaw areas, where it will not exceed
0.51 kg/kg, as determined in the testing program.

H. REPORTING RESULTS

1. Include in the test report tabulation as shown by the example below:

Cement Content (kg/m^3)	Slump, mm (Avg. of 3)	% Air (Avg. of 3)	W/C kg/kg (Avg. of 3)	14-day Compr. Str., MPa (Avg. of 6)	14-day Mod. of Rupture, MPa (Avg. of 6)
300	63	3.4	0.55	18.8	3.4
325	69	3.2	0.53	22.3	3.9
350	63	3.2	0.52	24.0	4.1

2. Also include in the test report a statement as follows:

"Based on the data obtained from California Test 536, the minimum recommended cement content for paving concrete using the aggregate indicated above is ___kg/m^3. If other sources of aggregate are used or intermingled, additional testing will be required."

I. SAFETY AND HEALTH

Freshly mixed concrete is an alkaline material and can cause dryness of the skin, dermatitis or chemical burns. Wear rubber gloves for protection.

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

REFERENCES:
AASHTO Designations: T 97 and T 126
ASTM Designations: C 39, C 143, C 173, and C 231
Caltrans Standard Specifications
California Tests 206, 207, and 518

End of Text (California Test 536 contains 3 pages)